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SIANGCHIN, KEVIN	
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10

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)
	09/681,108	DANCE, CHRISTOPHER R.
	Examiner	Art Unit
	Kevin Siangchin	2623

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☐ Responsive to communication(s) filed on _____.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *2-5,7-9,12-15,17-19 and 21-26* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *2-5,7-9,12-15,17-19,21,22,24 and 26* is/are rejected.

7)☒ Claim(s) *23 and 25* is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *10 May 2004* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)

2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)

3) ☐ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date _____.

4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.

5) ☐ Notice of Informal Patent Application (PTO-152)

6) ☐ Other: _____.

Detailed Action

Drawings

Response to Amendments to the Drawings

1. The replacement drawings were received on May 10, 2004. These drawings are acceptable.

Specification

Response to Amendments to the Specification

2. The amendments to the specification filed on May 10, 2004 have been acknowledged. The amendments introduce no new matter.

Claims

Response to Amendments to the Claims

3. The amendment to the claims filed May 10, 2004 has been entered into the record and claims 2, 4-5, 7-9, 12, 14-15, and 17-19 have been amended accordingly. Claims 1, 6, 10, 11, 16, and 20 have been cancelled. Claims 21-26 have been added.

Response to Arguments and Remarks

4. ***Claim Objections and Rejections Under U.S.C. § 112(2).*** By canceling claims 6 and 16, the Applicant overcomes all objections made in the previous Office Action with regard to these claims. The Applicant's amendments to claims 4 and 14 overcome the objections and U.S.C. § 112(2) rejections made

in the previous Office Action with regard to these claims. However, as shown below, new informalities and issues relating to clarity arise in the amended and/or new claims.

5. ***In Response to the Applicant's Remarks Relating to the Original Rejections Under U.S.C. § 102(b) and U.S.C. § 103(a).*** The Applicant's arguments filed on May 10, 2004 have been fully considered. These arguments will be addressed here, though, as will be shown below, they are moot in light of the new grounds of rejection.

6. Before proceeding, note that in response to the Applicant's arguments only remarks made with regard to claim 12 will be treated. However, since claim 2 puts forth essentially the same limitations as claim 12, the Applicant should appreciate that the following arguments apply to claim 2, as well.

7. Amended claim 12 essentially combines the limitations of original claims 11 and 12. The Applicant further limits the claimed method by insisting that the linear transformation coefficients be computed without interpolating pixels of another channel that have not been recorded (e.g. those that have been obtained by previously interpolating pixels of another channel – Claim 12[1] and Section 3, paragraphs 4-5 on pages 10-11 of the Applicant's response). The Applicant asserts that, for this reason, Adams fails to teach a CFA reconstruction method that complies to the limitations of amended Claim 12).

8. The Applicant correctly points out that a CFA reconstruction method, employing equations (9)-(11) of Adams, "assume[s] that the luminance channel interpolation has already been performed so that all the green pixel values are defined" (Adams page 147, paragraph 1). Such a method would not conform to that of claim 12 because, as the Applicant has pointed out, the linear transformation[2] coefficients are computed with an interpolation involving pixels of another channel that have not been recorded (i.e. the previously interpolated green channel pixels). However, Adams discusses several other approaches to CFA reconstruction, including methods where the coefficients of the linear transformation are computed only using pixels that have been recorded (e.g. estimates obtained by a prior interpolation). The Bilinear

1 Note the U.S.C. § 112(2) rejection below.

2 Recall that the linear interpolation method using equations (9)-(11) of Adams was taken to be a linear transformation in the previous Office Action. In other words, equations (9)-(11) of Adams were taken to collectively represent a linear transformation from the set of sampled pixel values to the set of unsampled pixel values.

Interpolation discussed on page 146 of Adams falls into this category. It can be shown that the bilinear interpolation of Adams equations (4)-(7) satisfies the mathematical conditions for being a linear transformation (i.e. the preservation of addition and the preservation of scalar multiplication). Furthermore, notice from equations (4)-(7) that the bilinear interpolation involves only sampled, recorded pixels (i.e. G2, G4, G6, G8, B1, B3, B7, B9). It does not require a previous interpolation to obtain estimates of missing (un-sampled, un-recorded) pixels. Therefore, while the CFA reconstruction method discussed in Section 3.4 of Adams (i.e. *smooth hue interpolation*) fails to satisfy this requirement of claim 12, Adams' bilinear interpolation does indeed satisfy this requirement. Despite this, the Applicant will notice that the bilinear interpolation coefficients in equations (4)-(7) or Adams are not dependant on any of the pixel values. Rather, the coefficients are constants (e.g. ¼ in equations (4)-(5) and ½ in equations (6)-(7)). Therefore, coefficients of the bilinear interpolation proposed by Adams are *not* computed using "the one of the plurality of color channels of sample values of pixels in the image". And, it is in this manner that Adams fails to teach a CFA reconstruction method satisfying the limitations of claim 12. Adams nonetheless teaches CFA reconstruction methods using a linear transformation to derive estimates of non-sampled, un-recorded pixel values from the set of sampled pixel values. As will be shown below, using these teachings in conjunction with the teachings of Kirk (U.S. Patent 4,803,548) one can obtain a CFA reconstruction method that is in accordance with that of claim 12.

9. Amended claims 2, 12, and 21 will be further addressed in the prior art rejections that follow.

10. As a final remark on the language of amended claim 12, the Applicant should notice that, although the limitation "without interpolating values of other color channels of such pixels not recorded in the image" substantively changes the scope of original claim 12, it does not appreciably contribute to the definition of the claimed CFA reconstruction method, at least as it is disclosed in the Applicant's specification. Rather, the limitation essentially defines what the claimed method is not. It appears, at first blush, that this limitation was added not to further define the Applicant's claimed invention, but instead to overcome the teachings of Adams. Furthermore, the limitation seems somewhat "out of place". Notice that, according to claim 12, coefficients of a linear transformation are computed "without linear interpolating

values of other color channels of … pixels not recorded in the image". Nothing in the Applicant's disclosure, nor in Adams, would seem to indicate that these coefficients would ever be computed with or by linearly interpolating values of color channels of unrecorded pixels. Even the smooth hue interpolation (Adams Section 3.4) that the Applicant faults does not compute coefficients by linearly interpolating the values of unrecorded pixels. Rather, the coefficients (e.g. ½ (B1/G1 + B3/G3) in equation (9) of Adams) are computed using pixel values (which may have been the result of a previous interpolation) according to relations (e.g. ½ (B1/G1 + B3/G3)) that can be trivially extrapolated from Adams' equations (9)-(11). In general, linear interpolation is used, within the context of the methods shown by Adams and other interpolative CFA reconstruction methods, to interpolate the known (recorded, sampled) pixel values to obtain the missing (unrecorded, un-sampled) pixel values. In these methods, the interpolation becomes the linear transformation used to "estimate a color channel not recorded" from the "sampled values output from a color filter array". Finally, note that the limitation, "without interpolating values of … pixels not recorded in the image", also imposes a somewhat rigid definition of the Applicant's claimed invention. The current language precludes interpolations involving *not-recorded* (e.g. previously estimated or interpolated) pixels from the computation of the linear transformation coefficients, yet would permit interpolations involving, say, *recorded* pixels. It is suggested that the Applicant focus on defining the claimed CFA reconstruction method and apparatus within the scope of the submitted specification and what is well-known in the art. For example, by claiming the Applicant's proposed method as a *non-interpolative* method for reconstructing color filter array images, the Applicant would accurately describe the claimed method and *may* distinguish it from interpolative methods (though it would *not* necessarily be non-obvious over prior art methods – see the U.S.C. § 103(a) rejections below), without introducing extraneous limitations having less to do with the Applicant's disclosed method than the methods of others. Similar statements can be made for claims 2 and 21.

<u>Objections</u>

11. Claims 4 and 14 are objected to because of the following informalities. The variables b_r' and b_b' appear in the first and second equations, respectively, of amended claims 4 and 14. However, subsequent equations contain the variables b'_r and b'_b. Although it is clear that these were intended represent the same

values, they can easily be interpreted as being different. The ′ notation is often used to denote mathematical operations such as derivatives or matrix transposition. Clearly, no such operations are performed in the Applicant's claimed invention. However, the placement of the ′ character may imply some unintended mathematical operation such as those just mentioned. Therefore, if the Applicant chooses to keep this notation, it should be consistent throughout the disclosure. Since the former (i.e. b_r' and b_b') is used in the Applicant's specification, it is suggested that this form be used throughout the claims.

12. The Applicant has chosen to use b to denote both a linear transformation coefficient (i.e. b_r' and b_b') and the blue color channel (e.g. as in Claim 14, lines 6-7). To avoid any potential confusion it is suggested that the Applicant use some notational device to distinguish between the two. A simple suggestion would be to change the b denoting the blue color channel to B (e.g. change b_b' to b_B' and remove the phrase "(or 'b')" from claims 4 and 14). This would be consistent with the other parts of claims 4 and 14. A similar change should be reflected in the Applicant's specification.

13. Claims 24 and 26 are objected to because of the following informalities. In these claims, the Applicant's phraseology of item (b) is unnecessarily awkward (there are, perhaps, too many prepositional phrases and the word *against* is improperly used: a line would not be fit to one set of values *against* the other set of values) and, as a result, obscures the meaning of claims 24 and 26. According to item (b), a line is fit to the sums of pixel values corresponding to one color channel and the sums of pixel values corresponding to the other color channel. The current wording can be read as though there is a "window of one color channel" and a window of "the other color channel". Clearly, this is not what was intended. Item (b) should indicate that a line is fit to the sums of pixel values corresponding to one color channel and the sums of pixel values corresponding to the other color channel.

<u>Rejections Under 35 U.S.C. § 112(2)</u>

14. The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

15. Claims 2, 4 12, and 14 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

16. *The following is in regard to Claims 2 and 12.* These claims recite the limitation: "without interpolating values of other color channels of *such* pixels not recorded in the image". However, according to these claims (e.g. Claim 2, lines 4-5), "each pixel in the image having a location at which a sampled value of one of a plurality of color channels is *recorded*". These portions of claims 2 and 12 seem to contradict one another. Specifically, the language of these claims implies that *such* pixels (referring presumably to the previous instance of the word *pixels* – i.e. "pixels in the image having locations at which a sampled value of one of a plurality of color channels is recorded" [e.g. Claim 2, lines 4-5]) would then be simultaneously recorded and not recorded. Removal of the word *such* may resolve the apparent contradiction.

17. Claim 12 recites the limitation "the image recording module" in lines 12-13. There is insufficient antecedent basis for this limitation in the claim. It will be assumed, henceforth, that a color channel value "recorded by the image recording module" means that the color channel been sampled and recorded.

18. *The following is in regard to Claims 4 and 14.* The amendments have added equations for $G(y,x)$ to these claims. Again, the Applicant has failed to include definitions for each of the variables of these equations (i.e. y, x, $R(\ )$, $B(\ )$, and $G(\ )$). As a result, the meaning of the equations cannot be ascertained.

<u>Rejections Under 35 U.S.C. § 103(a)</u>

19. Reference will be made to the previous Office Action, which is incorporated herein in its entirety. Reference will also be made to the discussion above in response to the Applicant's arguments.

20. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action.

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

21. Claims 2-3, 5, 7-9, 12-13, 15, 17-19, 21-22, 24 and 26 are rejected under 35 U.S.C. 103(a) as being unpatentable over Adams ("Interactions Between Color Plane Interpolation and Other Image Processing Functions in Electronic Photography", SPIE Vol. 2416, July 1995), in view of Kirk (U.S. Patent 4,803,548).

22. *The following is in regard to Claim 12.* Adams discloses several methods for the reconstruction of color filter array (CFA) images (Adams Abstract). Generally, these methods involve:

(12.a.) Recording an image of sampled values (Adams Sections 1.1 and 2.1) output from a CFA (e.g. a Bayer pattern CFA – Adams Fig. 1), wherein each pixel (i.e. each block of the Bayer pattern depicted in Adams Fig. 1) in the image has a location at which a sampled value of one of a plurality of color channels (i.e. R, G, B *color planes* – Adams Fig. 1 and Abstract) is recorded. These processes are inherent to the operation of a CFA and are typical to most methods of CFA reconstruction.

(12.c.) Using a linear transformation (e.g. an interpolation - Adams Section 2.2) and sampled values (i.e. the samples indicated by the Bayer pattern depicted in Adams Fig. 1), at the location of a selected pixel (e.g. any of the pixels of the Bayer pattern shown in Adams Fig. 1) in the image, to estimate a color channel value that not been sampled and recorded at the location of the selected pixel (Adams Section 1.3, paragraph 1, sentences 1-4). It can be trivially shown that linear interpolations (e.g. linear, bilinear, trilinear, or *smooth hue transition interpolation*) satisfy the mathematical conditions for being linear transformations (i.e. preservation of addition and preservation of scalar multiplication).

23. As discussed above, Adams does *not*, however, expressly show or suggest:

(12.b.) Computing coefficients of a linear transformation using one of the plurality of color channels of sampled values of pixels in the image without interpolating values of other

color channels of pixels that were not recorded in the image.

24. Kirk discloses a method of enhancing an image defined by luminance and chromaticity information, wherein, for a given region of the image (i.e. a window) the following is done (Kirk column 1, lines 44-47):

(12.b.) Computing coefficients (e.g. C_0, C_1, etc. – Kirk column 2, lines 30 and 34-35) of a linear transformation (Kirk column 2, lines 30 and 35-38) using one of the plurality of color channels of sampled values of pixels in the image (e.g. sampled luminance and chrominance (Kirk column 2, lines 35-38). Linear regression (Kirk column 2, lines 25-38) is used to derive this linear transformation, as opposed to an interpolating values of other color channels of pixels that were not recorded in the image.

25. The teachings of Kirk and Adams are combinable because they are analogous art. Specifically, Kirk, like Adams, discloses a methodology, whereby a full resolution image (Kirk column 1, lines 14-15 and 22-24 and column 3, lines 6-10) is reconstructed from a lower resolution set of samples (e.g. pixels of the CFA) through the application of a derived linear transformation. Therefore, it would have been obvious to one of ordinary skill in the art, at the time of the applicant's claimed invention, to use regression analysis as Kirk does, to reconstruct a full resolution set of pixel values from the relatively sparse set of CFA pixels.

26. In general, the effectiveness of an interpolation technique is a function of the spatial resolution of the set of known points. The effectiveness of interpolation, therefore, degrades when sets of color information (e.g. a sampled color plane) are sparse or the samples are spatially distant. Thus, the quality or effectiveness of a CFA image reconstruction method is directly related to the spatial resolution of the CFA image, which, in turn, is related to the density of costly CCD sensors. Clearly, it would be desirable to have a method for deriving an estimated relation between color channels that is independent of the spatial resolution of the sampled CFA image. Since the linear model obtained by the aforementioned regression analysis is not spatially dependent, one would expect that it would be less prone to the degradation exhibited by interpolation techniques, and hence less sensitive to the spatial resolution of the sampled CFA image.

27. *The following is in regard to Claim 13.* As shown above, the teachings of Kirk and Adams can be combined so as to adequately satisfy the limitations of claim 12. The regression analysis of Kirk involves

computing coefficient (e.g. C_0, C_1, etc. – Kirk column 2, lines 30 and 34-35 – or C_{0Q}, C_{1Q}, C_{0I}, and C_{1I} of the equations listed in Kirk column 4[3]) by statistics that depend on the sampled value (Kirk column 1, Summary of Invention, items (a) and (b)). It is well-known (see the discussion in the previous Office Action and below with regard to claim 14) that fitting a line to, as Kirk does, to sets of data values relies strictly on the data values and their statistical relations to one other. Generally, these methods do not incorporate spatial information (e.g. position) relative to the data values (unless, of course, the data value are spatial in nature). Kirk's method derives the linear transformation, including its coefficients and any associated statistical information, within a region (Kirk column 1, line 47 and column 4, lines 5-9 and 50-53) of the image having a predetermined size (i.e. a window of the image). It would have been obvious to one of ordinary skill in the art, at the time of the applicant's claimed invention, to compute perform linear regression within a window of the image, as opposed to, say, the entire image, because the derived model would account for local distributions of color.. One would expect that on a local sale, the color variation would be minimal and, correspondingly, contain few outliers. However, on a global scale, the color variation may be severe. Thus, a global linear model (i.e. a linear model derived for the entire image) results in far more outliers than a series of linear models localized to windows within the image. Therefore, by localizing the linear model, in this fashion, the accuracy of the reconstruction is improved.

28. *The following is in regard to Claim 15.* As shown above, the teachings of Kirk and Adams can be combined so as to adequately satisfy the limitations of claim 12. As stated previously, the coefficients (e.g. C_{0Q}, C_{1Q}, C_{0I}, and C_{1I} of the Kirk equations (1)-(2)) are derived through regression analysis – that is, fitting a line (i.e. the linear transformation defined by Kirk equations (1)-(2)) to the available set of data values. This is typical of regression methods. According to Kirk's method, the data values are the average luminance $\bar{L}$ and the average chrominance components, $\bar{I}$ and $\bar{Q}$, of the window for which the linear transformation is derived. As stated in the previous Office Action (page 8, paragraph 26), these values represent *weighted* sums. In computing averages, such as $\bar{L}$, $\bar{I}$, and $\bar{Q}$ in image regions – particularly rectangular or square regions (Kirk column 3, lines 14-15), color channel information (e.g. *L*, *I*, or *Q*) is typically accumulated sequentially along lines through the region (e.g. along rows then along columns, or

3 These equations will be referred to in this document as Kirk equation (1) and equation (2), respectively

vice versa). Therefore, it would have been obvious to one of ordinary skill in the art, at the time of the applicant's claimed invention, to fit the linear transformation to the average color channel samples ($\overline{L}$, $\overline{I}$, and $\overline{Q}$) of the region in question. The motivation for using these *local averages* in lieu of the samples themselves would have been to smooth (i.e. reduce noise) the fitted data (Kirk column 2, lines 39-43). Again, the elimination of potential outliers (i.e. those introduced by noise) improves the accuracy of the derived model.

29. *The following is in regard to Claim 18.* As shown above, the teachings of Kirk and Adams can be combined so as to adequately satisfy the limitations of claim 15. Kirk measures the *goodness-of-fit* of the derived model to the sampled pixel values (Kirk, column 3, lines 22-29 and column 4, lines 34-40). This goodness-of-fit measure (e.g. sum of the squares of differences between the linear model and the data – Kirk column 4, lines 36-39) can be shown to represent "one or more of a confidence and a variance ... determined for the sums of the color channels". This was treated more thoroughly in the previous Office Action (paragraph 29, pages 9-10). Furthermore, it is standard practice to determine the goodness-of-fit (e.g. via χ^2 goodness-of-fit tests, etc.) of a regression model to the data from which the model is derived, which in the case of Kirk are the average luminance and chromaticity data values, $\overline{L}$, $\overline{I}$, and $\overline{Q}$. It would, therefore, have been obvious to one of ordinary skill in the art, at the time of the applicant's claimed invention, to measure the *goodness-of-fit* of a derived linear model to the data values (i.e. averages $\overline{L}$, $\overline{I}$, and $\overline{Q}$). The motivation for doing so would have been to evaluate the validity of the derived linear model.

30. *The following is in regard to Claim 19.* As shown above, the teachings of Kirk and Adams can be combined so as to adequately satisfy the limitations of claim 15. As mentioned previously, the local averages $\overline{L}$, $\overline{I}$, and $\overline{Q}$ used to derive the linear transformation of Kirk are weighted sums. These averages correspond to subsidiary regions within a given window (Kirk column 4, lines 4-12). Generally, when computing an average of pixel values in a region of an image, pixel values are accumulated sequentially –

either along rows then columns of the region, or vice versa[4,5] – then appropriately weighted.

31. *The following is in regard to Claim 26.* As shown above, the teachings of Kirk and Adams can be combined so as to adequately satisfy the limitations of claim 19. As mentioned above with regard to claim 19, the local averages $\overline{L}$, $\overline{I}$, and $\overline{Q}$ used to derive the linear transformation of Kirk are weighted sums. These averages correspond to subsidiary regions within a given window (Kirk column 4, lines 4-12). Generally, when computing an average of pixel values in a region of an image, pixel values are accumulated sequentially – either along rows then columns of the region, or vice versa. This involves:

(26.a.) Determining sums of pixel values of two color channels (e.g. $\overline{L}$ or $\overline{I}$ or $\overline{Q}$) along those rows and columns (see above) of the window or region that contains samples of both color channels. It should be clear that, by being a subset of the sampled CFA image (e.g. Adams Fig. 1), the window or region contains samples of both colors *L, I,* or *Q*[6].

(26.b.) Fitting a line to the sums of pixel values, corresponding to one color channel (e.g. averages or weighted sums, $\overline{L}$, of luminance values) and the sums of pixel values, corresponding to the other color channel (e.g. the averages or weighted sums, $\overline{I}$ or $\overline{Q}$, of chrominance values). See Kirk equations (1)-(2) and Fig. 2.

This is the result of the regression analysis used by Kirk.

32. *The following is in regard to Claim 17.* As shown above, the teachings of Kirk and Adams can be combined so as to adequately satisfy the limitations of claim 26. As discussed above, Kirk shows that the pair of sets of color channel sums (e.g. the averages or weighted sums, $\overline{L}$ and $\overline{I}$; or the averages or weighted sums $\overline{L}$ and $\overline{Q}$) is fit using least squares linear regression (Kirk column 4, lines 13, 25 and column 3, lines 27-28).

4 Intuitively, this make sense, particularly when taking into account the fact that images are typically represented discretely as two-dimensional arrays of pixel values or color channel information.

5 Furthermore, though it is not expressly suggested by Kirk, the subsidiary regions can clearly be chosen as rows or columns through the given window.

6 Note that *L, I, Q* values are analogous to the R, G, B values used by Adams. They are simply different color space representations of the sampled pixel values. *L* and G represent the luminance channels of their respective color space, whereas *I,Q* and R,B represent the chrominance channel. Conversion between the two color spaces is a well-known and trivial linear operation.

33. *The following is in regard to Claim 21.* Following the discussion above, with regard to claim 12, the teachings of Adams can be combined with those of Kirk, to yield a CFA reconstruction method comprising:

(21.a.) Recording an image (i.e. acquiring and image) of sampled values output from a CFA. As depicted in Adams Fig. 1, the CFA records samples of a plurality of color channels (e.g. R, G, B) with only one sample of the plurality of color channels (e.g. R, G, B) begin samples at each pixel (e.g. each block of the Bayer Pattern shown in Adams Fig. 1) in the image.

(21.c.) Using the color channels of recorded samples to estimate coefficients for a linear transformation for the window assigned to the selected pixel in the image with out interpolating values for the other of the plurality of color channels not recorded in the image (see the discussion relating to item (12.b.) of claim 12). As discussed above (see the discussion relating to claim 15), the linear transformation and its coefficients are derived for regions (i.e. windows) of the sampled, recoded CFA image

(21.c.) Estimating a value for one or more of the plurality of color channels nor recorded at the selected pixel location (see the discussion above relating to item (12.c.)) with:

1. The recorded sample at the selected pixel location (Kirk column 4, lines 28-36).
2. The linear transformation for the window (e.g. equations (1)-(2) of Kirk) assigned to the selected pixel.

Kirk further demonstrates:

(21.b.) Assigning a selected pixel (e.g. pixel 2 of Kirk Fig. 1) in the image to a window (e.g. a region of the image – Kirk column 2, lines 39-44 and Fig. 1). The window may overlap other windows assigned to other pixels in the image (Kirk column 4, lines 49-53).

A justification was provided above as to the combinability Adams' and Kirk's teachings. The motivation to combine these teachings was likewise provided. Please refer to the discussion above relating to claim 12.

34. The advantage of using an *overlapping* window is (at least) twofold. First, overall – that is, taking into account all windows – overlapping windows produce a greater density of data being modeled. To see this, note that for each window a certain number of data points are generated (i.e. the averages or [weighted] sums, $\bar{L}$, $\bar{I}$, and $\bar{Q}$) and used to derive the corresponding linear transformation (according to Kirk equations (1)-(2)). By allowing the windows to overlap, more windows and, consequently, more data points exist *per image*. Generally, in any modeling scheme, a greater density of data points improves the accuracy of the derived model. Secondly, by allowing the windows to overlap, the linear model derived for a current window will incorporate information from the previous window. This ensures some degree of continuity between the derived linear models and would have the effect of *softening* the transition between models derived for successive regions. This softening would, in turn, manifest itself as a smooth transition of reconstructed colors across successive regions of the image.

35. *The following is in regard to Claim 22.* As shown above, the teachings of Kirk and Adams can be combined so as to adequately satisfy the limitations of claim 21. Note that claim 22 recites essentially the same limitations as claim 15. Therefore, arguments analogous to those presented above with regard to claim 15 apply.

36. *The following is in regard to Claims 2-4, 5, 7-9, and 24.* These claims recite essentially the same limitations as Claims 12-14, 15, 17-19, and 26, respectively. (These merely claim apparatuses that implement the methods proposed in Claims 12-14, 15, 17-19, and 26). Therefore, with regard to Claims 2-4, 5, 7-9, and 24, remarks analogous to those presented above relating to Claims 12-14, 15, 17-19, and 26 are applicable.

37. Claims 4 and 14 are rejected under 35 U.S.C. 103(a) as being unpatentable over Adams, in view of Kirk, in further view of Weisstein ("CRC Concise Encyclopedia of Mathematics", 1999).

38. *The following is in regard to Claims 4 and 14.* As shown above, the teachings of Kirk and Adams can be combined so as to adequately satisfy the limitations of claim 3 and 13.

39. Note that, other than the first two equations, amended Claims 4 and 14 do not introduce any additional limitations over original Claims 4 and 14. The amendments primarily address U.S.C. § 112(2) issues alluded to in the previous Office Action. It was shown, rather extensively, that the latter set of equations, carried over from original claims 4 and 14, are alternative expressions of known formulae for linear regression coefficients. The details will be omitted here. Please refer to the discussion in the previous Office Action relating to original claims 4 and 14 (previous Office Action, pages 10-12). Furthermore, it should be clear that the first two equations of amended claims 4 and 14 are similar in mathematical form and purpose to equations (1) and (2) of Kirk. Specifically, $G(y,x)$, $R(y,x)$ and $B(y,x)$ correspond to $\bar{L}$, $\bar{I}$, and $\bar{Q}$ (or $\bar{L}$, $\bar{Q}$, and $\bar{I}$; the difference between this and the former combination is inconsequential), respectively; and a_r, a_B, b_r' and b_B' correspond to C_{1I}, C_{1Q}, C_{0I}, and C_{0Q}, respectively. These are simply equations for the lines fitted to the two chrominance channels and the luminance channels. Their form is similar, if not identical, to the equations typically used in linear regression (e.g. Weisstein equations (19) and (45) on pages 1047-1048).

Allowable Subject Matter

Objections, Allowable Subject Matter

40. Claim 23 and 25 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

41. The following is a statement of reasons for the indication of allowable subject matter.

42. Kirk uses a *goodness-of-fit* ("confidence") measure (Kirk column 3, lines 25-29 and column 4, lines 32-44) to essentially "determine … which of sums of the rows or columns [i.e. averages $\bar{L}$, $\bar{Q}$, and $\bar{I}$]of the window to select to fit a line thereto". This is typical of regression methods, where a *confidence*

measure is used to eliminate outliers from the derivation of the regression model. This aspect of claims 23 and 25 is *not* unique.

43. However, the teachings of Kirk, Adams, Weisstein, and all other encountered prior art fail to show, suggests or imply "selecting rows or columns of the window that have a low variance within their sum of color channels". Despite this, it can be readily understood, at least within the context of Kirk's methodology, why such a selection would be advantageous. Rows or columns that vary considerably have luminance and/or chrominance values that differ appreciably from the average luminance and/or chrominance values (i.e. $\bar{L}$, $\bar{Q}$, and $\bar{I}$). In this case, the average luminance and average chrominance values (i.e. $\bar{L}$, $\bar{Q}$, and $\bar{I}$) would not provide an accurate measure of the luminance and chrominance information within the image region being modeled. Therefore, by basing the regression on data points (i.e. $\bar{L}$, $\bar{Q}$, and $\bar{I}$), corresponding to image regions (or more specifically subsidiary regions – Kirk column 4, lines 8-9) – rows and columns – having low variance, one can obtain a more accurate linear model. A similar justification applies to selection of rows and columns in the Applicant's claimed invention.

Conclusion

44. **THIS ACTION IS MADE FINAL.** Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

45. A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Kevin Siangchin whose telephone number is (703)305-7569 The examiner can normally be reached on 9:00am - 5:30pm, Monday - Friday

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Amelia Au can be reached on (703) 308-6604. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

Kevin Siangchin

Examiner
Art Unit 2623
ks – 08/27/04

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